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Research Document 2001 /030 | **Document de recherche 2001 / 030**

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Assessment of the status of the Atlantic salmon stock of Conne River, SFA 11, Newfoundland, 2000

Évaluation de l'état du stock de saumon atlantique de la rivière Conne River (ZPS 11), à Terre-Neuve, en 2000

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ISSN 1480-4883
Ottawa, 2001

Canada

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Abstract

Results obtained from a fish counting fence provided the basis for the assessment of the Conne River Atlantic salmon stock in 2000. Total returns to home waters (river and estuary) were 5177 salmon < 63 cm in length and 216 salmon ≥ 63 cm in size. This represented an increase of 120% for small salmon by comparison with 1999 and the highest return since 1990. Returns of large salmon declined by 10% from the previous year. Sea survival to 1SW salmon increased to 7.8%, the second highest value recorded and well above the mean survival of 3.6% for the 1991 to 1999 adult salmon return years. Both the management target (117%; 89-147%) and conservation spawning (egg) requirement (210%; 160-264%) were attained. A mark-recapture study estimated a smolt run in 2000 of 60,777, about 40% less than the peak run in 1997 and approximately 14% below the long term average production (70,890) from 1987 - 1999.

Résumé

L'état du stock de saumon atlantique de la rivière Conne en 2000 est évalué d'après les données recueillies à une barrière de dénombrement du poisson. Au total, 5 177 saumons < 63 cm de longueur et 216 saumons > 63 cm de longueur sont revenus frayer dans leurs eaux natales (rivière et estuaire), ce qui représente, dans le cas des petits saumons, la plus forte remonte depuis 1990 et une augmentation de 120 % par rapport à 1999, mais dans le cas des gros saumons, d'une baisse de 10 % par rapport à l'année précédente. La survie en mer jusqu'au stade d'unibermarins est passée à 7,8 %; cette valeur, la deuxième plus forte observée, se situe largement au-dessus du taux de survie moyen des adultes de 3,6 % signalé pour les années de remonte 1991 à 1999. L'objectif de gestion (117 %; 89-147 %) et de ponte aux fins des besoins de conservation (210 %; 160-264 %) ont tous deux été atteints. Selon une étude de marquage et de recapture, la remonte estimative de smolts en 2000 se chiffrait à 60 777 individus, soit environ 40 % de moins que la remonte de pointe de 1997 et environ 14 % de moins que la production moyenne à long terme (70 890) de 1987 à 1999.

Introduction

Conne River, SFA 11 (Fig. 1) flows into Bay d'Espoir on the south coast of Newfoundland. It is a sixth-order river with a drainage area of 602 km^2 and a total length of 193 km. Since 1986, a fish counting fence has been operated to enumerate the upstream migrating population of Atlantic salmon (*Salmo salar*). Previous estimates of total returns of small salmon have ranged from a low of 1533 in 1994 to a high of 10155 in 1987. Mark-recapture studies were initiated in 1987 to survey the number of out migrating smolts and continued in 1998. Smolt production has varied from about 56 thousand in 1993 to 101 thousand in 1997.

Conne River is assessed relative to a **management target** (MT) as well as a **conservation spawning requirement.** The latter differs and is lower than the management target. The management target was based upon the estimated number of spawners required to produce the highest recorded returns to the river, which occurred in 1987. The returns were adjusted to account for the total population prior to any sea fisheries by using an assumed commercial exploitation rate.

The management target was met or exceeded from 1986-90, declined to 40% in 1994 and has been attained only once during the period from 1995 to 1999 (Dempson et al. 2000). In contrast, the conservation spawning requirement was achieved from 1986-90, in 1993, and again in each of the years from 1995 to 1999

A major change in the management of the Conne River Atlantic salmon stock for 1993 was the complete closure of the recreational fishery. In light of the forecast of low salmon returns in 1994 and 1995, this closure was continued and extended to the Indian Band Council's food fishery. Both fisheries remained closed in 1996 and were again closed in 1998 and 1999. A limited food and recreational fishery was allocated for 1997. While pre-season forecasts of Conne River salmon abundance were not provided for 2000, it was acknowledged that marine survival rates of 3.9% and 6.3% would need to occur in order for the conservation requirement and management target to be attained, respectively.

This paper summarizes smolt production and returns of adult Atlantic salmon to Conne River in 2000. Information on environmental characteristics during the 2000 season is also provided, and biological characteristic data for Atlantic salmon are updated including some data from past years. Results from 2000 season are addressed relative to the **management target** as well as the **conservation spawning requirement**. Information on the occurrence of escaped farmed steelhead (rainbow) trout and Atlantic salmon in Conne River is also updated.

2000 Highlights

The following summarizes highlights to fishery regulations and other observations/events occurring in 2000:

- recreational fishery opened for the first time since 1997;
- sea survival from smolts (migrating in 1999) to 1SW salmon returns in 2000 was the highest in over a decade increasing to 7.8%;
- 117% of the **management target** was achieved in 2000 while 210% of the **conservation spawning (egg) requirement** was attained;
- smolt production in 2000 declined by about 5% from the previous year but has declined by 40% since the peak production recorded in 1997;
- egg-to-smolt (freshwater) survival fell coincident with an increase in the egg deposition rate per unit of fluvial habitat;
- Arctic charr (*Salvelinus alpinus*) were recorded for the first time in the Conne River watershed in 1999, and an additional specimen was obtained at Camp 1 in 2000.

Methods

1. Landings

Information on recreational Atlantic salmon catches in 2000 were reported by Native guardians from the Conne River Native Band Council. Previously, data were obtained from DFO and Native guardians.

2. Environmental conditions

Water temperature information was obtained from a continuous recording Hugrun thermograph located in the lower Conne River (March 29 - September 7, 2000) (Fig. 2). Information on air temperature, precipitation, and discharge was obtained from the Provincial Water Resources Management Division monitoring facility located on the main stem of Conne River, below Conne Pond.

3. Biological characteristics

Biological characteristic data on adult salmon returns in 2000, including fork length, whole weight, age (scales) and sex, were derived from sampling salmon captured at the fish counting fence and from samples obtained from the recreational fishery. Biological data on Atlantic salmon smolts were obtained from specimens sampled at the downstream fish counting fence trap.

Estimates of the numbers of salmon of different life stages (1SW, 2SW, consecutive and alternate spawners) that have returned to Conne River were obtained in a manner similar

to that used in previous years (Dempson et al. 1998, 1999, 2000) with modifications this year as explained below. Salmon returning to the river were initially categorized as either small (< 63 cm) or large (≥ 63 cm) salmon. Biological characteristic data were similarly partitioned into these respective size classes and applied to numbers of returning fish. Data were available for 2521 small salmon, and 170 large salmon.

For small salmon, year specific information was applied from 1986 to 1990, and 1995-2000. As in previous assessments, for the years 1991-1994, the average contribution for the years 1991-94 was used. Consecutive spawners within the small size category can spawn multiple times while still remaining within the < 63 cm size group (see Table 3b). Thus this year consecutive spawners within the small size category were apportioned back either one or two years coinciding with their original year in which they were virgin 1SW fish in estimating survival of repeat spawners (Table 5).

With respect to large salmon, numbers in each year were recalculated using the average values for the 1986-2000 period. Survival of repeat spawners was determined separately for consecutive spawning small salmon, and also by adding the subsequent numbers of consecutive and alternate spawners for both small and large salmon in each case relating the numbers back to the corresponding number of fish that originally spawned as virgin 1SW fish. As in the past, estimation of survival was constrained to the case where the consecutive or alternate spawners were associated with the previous 1SW component by a time span of either one or two years only. Within the small size category, 93.2% of all samples were virgin 1SW fish, 6.7% were consecutive spawners, and 0.08% (N = 2 of 2521 small sized specimens) were alternate spawners. In contrast, within the large salmon component, 75.3% were alternate spawners, 18.2% were consecutive spawners and 6.5% were 2SW fish. Owing to the dependence on using average values over all years for large salmon, it is more appropriate to use year-specific information for small salmon only to examine changes in the survival of previous spawners.

Condition of smolts was determined using Fulton's condition factor (K) as follows:

$$K = W \times C / FL^3$$

where, W = whole weight in grams; C = a constant, 100,000; and FL = fork length in mm.

4. Estimated total returns and spawning escapement

Adult Atlantic salmon migrants were enumerated at a fish counting fence, located about 1 km upstream from the mouth of the Conne River (Fig. 1), which operated from May 22 to August 19, 2000 (Table 1). The counting fence was monitored as a co-operative project between DFO and the Miawpukek Mi'kamawey Mawi'omi (Council of Conne River Micmacs).

During 2000, adult salmon were again counted either as they: 1) entered the trap directly; or 2) passed through openings in the fish counting fence but were recorded on the video camera system. The video camera system utilized a positive image horizontally directed camera (Panasonic model WV-BD400) positioned on the substrate and angled to view an opening in the fish counting fence. A Panasonic Time Lapse Video Recorder (Model AG 6040) was used to record the video signal from the camera and could also superimpose the time and date thus providing a summary of actual fish passage times. The video system was operated each day from June 9 until July 21 and generally from early evening until about 0900 hours the following morning.

Total river returns

Total river returns (TRR) of adult salmon were calculated as follows:

$$TRR = C + RC_b + Mb$$

where,
- C = the count of salmon at the counting fence
- RC_b = recreational catch below the fence
- Mb = known or estimated mortalities below the counting fence

A nonparametric bootstrap procedure was used in a retrospective manner to estimate the probability of achieving the total return of small salmon in 2000. One version was based on resampling, with replacement, smolt to small salmon survivals from the 1991 to 1999 adult return years (N = 9; Table 8) applied to the estimated smolt run in 1999 (63658; SD = 5282) with 1000 realizations. The second version was based on resampling survivals for all adult salmon return years, 1988 - 1999 (N = 12).

Spawning escapement

Spawning escapement (SE) was calculated as:

$$SE = FR - Ma$$

where,
- FR = the number of fish released at the counting fence
- Ma = the number of known mortalities (including angled salmon) above the fence

Consistent with the practise established in 1991, estimated egg deposition refers to the 'potential' deposition relative now to either the current **management target** or the **conservation spawning (egg) requirement**. That is, no additional adjustments have been made to account for any unknown or assumed mortality of fish up to the time of

spawning. Thus, the potential egg deposition could overestimate the actual egg deposition.

Egg deposition

As in past years, egg deposition (ED) was calculated separately for salmon < 63 cm and salmon ≥ 63 cm and then totaled.

$$ED = SE \times PF \times F$$

where, PF = proportion of females; F = fecundity at size

An estimate of fecundity was obtained from the relationship derived in 1987 (October 27-30) from ripe salmon (Dempson et al. 1987):

$$\text{Fecundity} = 0.1988(\text{fork length, cm})^{2.3942} \qquad (r^2 = 0.48,\ P < 0.001)$$

where fork length was the mean length of female salmon < 63 cm. For 2000, the mean length and proportion of females from all years were used ($\bar{x}$ = 50.9 cm; N = 1303, and includes repeat spawning females < 63 cm; percentage female was 77.5%, N = 1681).

An estimate of the egg deposition from salmon ≥ 63 cm in size was obtained using the same length-fecundity relationship for salmon < 63 cm, with the same percent females (71%) as used in past years (Dempson et al. 1998, 1999) but with mean size length data updated using the mean size of all large salmon sampled (69.1 cm, N = 170).

The **management target** has been maintained as in past years at **7.8 million eggs**, equivalent to about 4000 salmon < 63 cm in size.

The **conservation spawning (egg) requirement** (**ER**) was determined following the method summarized in O'Connell and Dempson (1995) for average potential smolt production:

fluvial habitat	=	13180 units	@ 3 smolt/unit
lacustrine habitat	=	3187 hectares	@ 7 smolt/unit

Corresponding egg deposition requirements were derived using egg-to-smolt survival rates of 0.0125 and 0.019 for fluvial and lacustrine habitats, respectively. The **conservation spawning (egg) requirement** is **4,337,358** eggs versus 7.8 million as a **management target**.

The equivalent total number of spawners (TNS) associated with the **conservation spawning (egg) requirement** has not changed and was calculated as follows:

$$TNS = \frac{ER}{[\,(PS \times PF_s \times F_s)\,]}$$

where,

PS = proportion small salmon (< 63 cm) in TRR, 1992-96 ($\bar{x}$ = 0.958)

PF_s = proportion female small salmon, 1992-96 ($\bar{x}$ = 0.769)

F_s = fecundity of small salmon at size ($\bar{x}$ length, 1992-96 = 50.5 cm, = 2379)

Thus, TNS = 2475 small salmon; large salmon are considered a buffer to spawning requirements.

5. Net-marked salmon and escaped farmed salmon and rainbow trout

Surveys of net-marked salmon returning to Conne River were carried out from June 7 - July 8, 2000, but only on those fish clearly observed in the fish counting fence trap. Similarly, salmon observed in the counting fence trap showing characteristic 'farmed fish' appearance (fin size, shape and form, body shape and pigmentation) are noted and removed from the river. Identity of these 'suspect' fish are subsequently confirmed by examination of scale circuli characteristics. **Note, given that salmon can pass freely through an opening in the fish counting fence used in conjunction with operation of the video camera system, not all escaped farmed salmon (or rainbow trout) are removed from the Conne River system.** In addition, examination of scales obtained from sampling salmon throughout the run are used in a retrospective manner to infer the presence of escaped farmed salmon in Conne River.

6. Smolt production

A mark-recapture study was carried out to estimate the smolt production in 2000. The study was similar to those carried out from 1987-99, the design of which is summarized in Dempson and Stansbury (1991) and uses the estimator described in Schwarz and Dempson (1994). Since 1995, the downstream smolt trap has been monitored 24 hours of the day.

During 2000, 3361 smolts were tagged and released at the upstream partial counting fence site (Fig. 1). At the downstream recapture site, 6168 smolts were caught including 400 tagged smolts. Owing to a high water event over a 5-day period from May 3 - 7, 2000, the smolt mark-recapture study was disrupted and an adjustment was incorporated to account for smolts migrating on these days. The average proportion of the run in past years for each day from May 3 - 7 was calculated and applied to the known count in 2000 to derive numbers of unmarked smolts caught on these days. An exception was for May 3, the first day of the high water event, where the proportion for this day was

doubled. For tag recaptures, the mean proportion of recaptures relative to the number of fish tagged and released for the previous (before the flood), and subsequent (after the flood) 5-day period was determined. Tag recaptures for May 3 - 5 were based on the period prior to the flood, while estimates of recaptures for May 6 -7 were based on the period after the flood. The adjustment contributes about 17% of the smolt run in 2000.

Results and Discussion

1. Landings of Atlantic salmon

Landings in the recreational fishery are summarized in Table 2. Harvest of over 2000 small salmon have been reported in some past years. In 2000, 730 small salmon were reported caught and retained; 420 below the fish counting fence and 310 salmon from upstream of the fence. We note that in past years, angling exploitation rates have varied from 0.181 to 0.285 (Dempson et al. 1994).

Native food fishery catches are also summarized in Table 2. The highest catch occurred in 1990.

2. Environmental conditions

Mean air temperature for the month of April was the third warmest since 1989. Much of this resulted from warmer temperatures during the first half of the month as the mean temperature for April 16 - 30 was the third coldest during the past 10-years (1991 - 2000). The average May air temperature was colder than each of the previous two years but warmer than those from 1994 - 1997. The air temperature index for the period April 1 to May 15, 2000, was similarly colder than that in 1998 and 1999 (Fig. 3b). The first day with a mean daily air temperature of over 10° C in 2000 was May 15. Water temperatures (Fig. 2) were generally cool until early May when average daily temperatures exceeded 8 °C from May 6 -10. Temperatures then increased with daily averages, for the most part, > 10 °C. The first day when the average daily water temperature exceeded 10°C (lower fish counting fence - Hugrun thermograph) in 2000 was May 11, 7 days later than in 1999.

Year	Mean air temperature °C				Median day Of smolt run Timing
	April	May	April 1 - May 15	April 16 - 30	
1986	5.11	7.70	5.60	8.51	-
1987	4.11	8.15	5.48	4.37	131
1988	3.18	10.08	4.77	3.55	136
1989	2.69	8.90	4.08	3.01	138
1990	2.28	6.36	3.46	2.72	138
1991	1.16	5.95	2.87	3.25	141
1992	0.36	7.77	2.36	0.67	145
1993	1.49	6.87	2.34	3.35	143
1994	1.17	6.21	2.69	2.28	142
1995	0.49	5.56	1.80	2.54	139
1996	3.09	5.82	3.69	5.02	124
1997	-0.36	5.87	1.59	0.43	146
1998	2.08	8.23	4.31	3.34	130
1999	2.56	10.46	4.86	3.39	126
2000	2.42	6.42	3.04	2.17	129
2001	0.63	7.01	2.79	2.62	

Water temperatures increased over the summer with the warmest temperatures occurring in the latter part of July and in early August (Fig. 2). During the period June 1 – August 31, mean daily water temperature exceeded 20 °C on 20 occasions (Fig. 2), while doing 30 times in 1999 and 29 times in 1998. A mean temperature of $\geq$ 22 °C occurred only twice. The maximum water temperature recorded in 2000 was on June 23 (24.6 °C).

High water events occurred in early May, mid-July and again around the third week of August (Fig. 2).

3. Biological characteristics

Adult samples

Table 3a summarizes annual biological characteristic data of Atlantic salmon from Conne River, 1986-2000. Mean weight of 1SW salmon in 1994 and 1995 is lower by comparison with earlier years. These weights were taken from salmon maintained in cages for brood stock and were recorded in September rather than in June or July as in past years.

Repeat spawning salmon are separated into consecutive and alternate categories. Consecutive spawners are typically less than 63 cm in fork length ($\bar{x}$ = 581 mm, Table

3a) while alternate spawners average 696 mm in length (Table 3a) (Fig. 4). As acknowledged in past reports, not all size classes of fish can be sampled representatively. However, with respect to salmon less than 63 cm in length, only 171 (6.8%) out of 2521 samples at Conne River were either consecutive (N = 169) or alternate (N = 2) spawning fish. Length-frequency distributions of 1SW, 2SW, consecutive, and alternate spawners sampled at Conne River are illustrated in Figure 4. Biological characteristics of fish separated by life-history groups for small and large salmon is shown in Table 3b. Large salmon are primarily alternate spawners (75.3%; N = 170) (Table 3b).

Survival of repeat spawning salmon has increased substantially since the mid 1990's but has fallen in recent years (Table 4). The most accurate information is derived from using consecutive spawning salmon from within the small size category only. Using these data, average survival has increased from 2.33% from 1986-90, to 16.85% for the years 1995-98, but declined to 9.2% in the most recent year.

O'Connell et al. (1997) examined inter-annual variation in fecundity for a variety of Newfoundland salmon rivers, including Conne River. Data (N = 536) from small salmon sampled during the early summer at Conne River were available from eight years (1986 - 1988, 1990 - 1992, 1997 and 2000) and were expressed in terms of number of eggs per female, as well as relative fecundity in terms of weight and length (Table 5). It was noted that there was a substantial decline in fecundity from 1988 to 1992 at Conne River. As indicated in Table 5, following the low fecundity values during the early 1990's, fecundity in 1997 was the highest recorded with a small decline noted in 2000.

Smolt samples

Smolt condition (Fulton's condition factor) has ranged from a high of 0.984 in 1988 to a low of 0.893 in 1992 (Fig. 3a). Smolt condition in 2000 (0.957) declined slightly from 1999 (0.967) but was still above the long term average condition over all years ($\bar{x}$ = 0.938; 1986-2000). Previously, it was noted that years in which smolts had a higher condition were often those that were associated with warmer spring temperatures (Fig. 3c). There was also an indication that smolt condition was associated with subsequent sea survival, as higher survival of smolts often occurred in years where condition was greater (Fig. 3d). The lower condition of smolts in 1997 was consistent with reduced survival that occurred with returning salmon in 1998. Condition of 1998 smolts was similar to the average over all years average (0.938) but survival of adult salmon returning in 1999 was correspondingly low. In contrast, condition of smolts in 1999 was high and coincidentally, perhaps, resulted in the highest marine survival rate observed in over a decade.

Run timing

Figure 5 illustrates the run timing of smolts and adult small and large salmon at Conne River. Variability in run timing is apparent for both groups with up to a 21 day difference in the 25th percentile of the run of smolts and 15 day difference in timing of small salmon returns. Median dates of the smolt run were typically later (7 days) during 1991- 1994 (May 21) in comparison with the pre-1990 period (May 14); the earliest smolt run occurred in 1996 while the latest run was in 1997. Smolt run timing in 2000 was the third earliest recorded to date (Fig. 5) but was spread out over a longer period of time by comparison with the past three years. The distributions of each of the annual smolt runs are shown in Figure 6.

Median run timing of small salmon in 2000 was among the earlier of those recorded since 1986 (Fig. 5). In general, run timing during the past three years has been about 11 days earlier than those from 1991-1997. Eighty (80%) of the run of small salmon was in by the end of June.

Median run timing of large salmon in 2000 was similar to that of small salmon (Fig. 5). From 1986-1996, median run timing of large salmon was about 5 days earlier than small salmon. However, during the past four years (1997-2000), run timing of large salmon has been about 2 days later than that of small salmon .

4. Estimated total returns, sea survival and spawning escapement

There were 4708 salmon < 63 cm and 216 salmon ≥ 63 cm counted at the fish counting fence on Conne River in 2000 (Tables 6 and 7). This represents an increase of 100% in the number of small salmon by comparison with 1999 while the number of large salmon decreased by 10%; the count of small salmon was highest since 1988. The single largest daily run occurred on June 28 (415 small salmon) (Fig. 7) with 80% of the run of small salmon complete by July 1. The distributions of past annual small salmon counts are shown in Figure 7.

Partitioning the count of salmon among the various ways fish were enumerated in 2000 is as follows:

	Small Salmon		Large Salmon	
	N	%	N	%
Fence opening	0	0	0	0
Counting fence trap	2373	50	154	71
Video camera chamber	2335	50	62	29
Total	4708	100	241	100

With respect to the video camera system, salmon again generally migrated all night long. During 2000, the period from 2230 to 0229 hours accounted for 56% of the total. A total of 2082 fish were associated with time of fish passage during the evening or throughout the night as follows: (remaining salmon enumerated by video camera outside of the hours shown below)

Time (hours)	Number of fish	%
2030 - 2229	227	10.9
2230 - 0029	620	29.8
0030 - 0229	546	26.2
0230 - 0429	490	23.5
0430 - 0900	199	9.6
Total	2082	100

Total returns (Fig. 8) of adult salmon to Conne River in 2000 are summarized in Tables 6 and 7 for small and large salmon, respectively.

Total returns of small salmon (5177) were more than double that of 1999, and were the highest obtained since 1990. Total returns of large salmon (216) were 10% less than 1999. The higher numbers of large salmon in recent years (1996-2000), can be attributed, in part, to the increased survival of repeat spawning salmon at Conne River in recent years (Table 4).

Results of the nonparametric bootstrap procedure based on resampling, with replacement, smolt to small salmon survivals from all years, 1988-1999 (N = 12) and applied to the 1999 smolt run, indicated that there was only a 10% probability of having 5170 small

salmon return in 2000. Given the trend for reduced survivals over the past decade, the results based on resampling from the 1991 to 1999 adult return years only (N = 9; Table 8), and again applied to the estimated smolt run in 1999, indicated that there was only about a 0.6% chance of having 5170 salmon return. Thus while it is common for salmonid populations to vary annually in abundance, based on past observations, there was only a small probability of having as many salmon return in 2000.

Sea survival

Sea survival from smolts to small salmon has varied from 2.7 to 10.2% (Table 8). Survival had increased from 2.7% (2.6-3.0%) in 1994 (adult return year) to 7.2% (6.4-8.3%) in 1996 but averaged only 3.2% during the past three years (Fig. 8, Table 8). Marine survival of adult small salmon that returned in 2000 was 8.1% (7.0-9.7%), the highest obtained in over a decade and the second highest reported. Corresponding sea survival to 1SW salmon was also the second highest achieved.

Spawning escapement

Potential spawning escapement in 2000 was 4431 small salmon and 216 large salmon (Tables 6 and 7). Mean number of eggs per female for the wild salmon was 2425 using average size data of females for all years.

small salmon = 8.32614 million eggs
large salmon = 0.77305 million eggs

for a total egg deposition of 9.10 million, representing 117% of the current **management target** or 210% of the **conservation spawning (egg) requirement** (Table 7). Note, some values in Table 6 and 7 may have changed slightly as a result of updating biological characteristic information on small and large salmon.

To account for some of the uncertainty in the potential egg deposition obtained, a coefficient of variation of 20% around the fecundity and percentage females of both small and large salmon was assumed, and the corresponding egg depositions recalculated using 1000 realizations from a uniform distribution. Based on this assumed level of variation, the corresponding 5th and 95th percentiles of the management target were 89%-147% achieved, and with 160%-264% of the conservation spawning requirement met.

Egg-to-smolt survival

Estimates of egg-to-smolt survival are now available for nine year-classes (1986 to 1994); a tenth year-class (1995) is complete only to age 4 smolts in 2000. These values, by year-class, are:

Year-class (eggs)	Estimated egg Deposition	Smolt Production	Survival (%)	Number of eggs per 100 m²
1986	11384887	57499	0.51	864
1987	17097439	76211	0.45	1297
1988	12379696	65237	0.53	939
1989	8012933	55006	0.69	608
1990	8714995	68021	0.78	661
1991	4012578	58776	1.46	304
1992	3755984	95707	2.55	285
1993	4760786	98561	2.07	361
1994	3116682	66139	2.12	236
1995	6368593	(68491)[1]	(1.08)	483
1996	8859057			672
1997	5437344			413
1998	6513054			494
1999	5280476			401
2000	9099186			690

[1] to age 4 smolts in 2000

Egg-to-smolt survival, has increased three-fold from the average of the 1986 to 1990 values (mean = 0.59%) to those obtained since 1991. The dramatic increase in the egg-to-smolt survival coincided with the first of several successive years in which the egg depositions were below the Management Target of 7.8 million eggs and has maintained this pattern until recently (Fig. 9). However, as noted last year (Dempson et al. 2000), the egg-to-smolt survival from the 1995 year class (eggs) was going to result in a much lower survival coincident with the increased egg deposition rate in that year. Smolts produced to date from the 1995 year class are complete to age 4 and the egg-to-smolt survival is only 1.08%, about half that which has occurred from the 1992-1994 year classes. As 1996 also had a moderately high egg deposition rate, and smolts produced to date are now complete to age 3, it is projected that the freshwater survival (egg-to-smolt) will fall to below 0.7%. The estimated number of smolts produced from varying egg deposition rates is illustrated in Figure 10. Both Figures 9 and 10 suggest that increased egg depositions do not necessarily result in higher smolt production.

5. Net-marked salmon and escaped farmed salmon and rainbow trout

The following summarizes observations of net marked salmon at Conne River during 2000.

Date	Number of fish observed	Number scarred	Percent Scarred
June 7-16	132	5	3.8
June 17-21	270	6	2.2
June 22-26	265	11	4.2
June 27-July 1	151	6	4.0
July 2-6	131	3	2.3
July 7-11	52	2	3.8
Total	1001	33	3.3

Numbers of net marked salmon varied on each occasion with no apparent increasing or decreasing trend. Results from 2000 are generally similar to those of 1999, and are among the lowest recorded (1994 = 18.6%; 1995 = 7.1%; 1996 = 6.2%; 1997 = 7.2%; 1998 = 3.7%; 1999 = 4.0%).

Escaped farmed salmon and rainbow trout

There were five (5) salmon identified as potential escaped farmed salmon from a post-season analysis of scale circuli characteristics out of a sample of 221 adult salmon sampled in 2000 (2.26%). Of these fish, two were salmon removed from the fish counting fence trap, two were samples obtained from anglers, and one was a mortality. A history of escaped farmed salmon identified at Conne River is provided in Table 9.

Table 10 summarizes the occurrence of escaped rainbow trout in Conne River in 1999 and 2000 and complements previous information summarized in Dempson et al. 1999 and Dempson et al. 2000.

6. Smolt production

The estimated number of smolts in 2000 was 60,777 (95% confidence limit = 51783-769771) and was slightly less than 1999 (Table 8). Smolt production has now declined by almost 40% from the peak run in 1997, with the run in 2000 about 14% less than the previous average ($\bar{x}$ = 70896, 1987-1999). The number of smolts and percentage in each age group is summarized in Table 11.

Based upon the point estimate of the number of smolts that migrated in 2000 (60,777), a marine survival rate of 4.1% is required in order for the conservation requirement to be attained while a marine survival of 6.6% will need to occur in order for the management target to be achieved in 2001. Based upon the sea survival rates that have resulted over the past 13 years (adult return years from 1988 to 2000), and without any consideration of the trend for lower survivals during the 1990's, the probability of achieving the above returns are 57% and 38%, for the conservation and management targets, respectively. These values fall to 41% and 19%, if the early years (1988-1990) are omitted from the sequence of survivals used.

Acknowledgements

We again wish to acknowledge the support and co-operation of the Miawpukek Mi'kamawey Mawi'omi (Council of Conne River Micmacs) during all aspects of the 2000 project. As in past years, Milton Shears and Roger Johnson provided valuable assistance during the smolt phase of the project.

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Table 1. Summary of dates of operation for downstream smolt mark-recapture studies, and upstream adult salmon counts at Conne River, Newfoundland, 1986 - 2000.

Year	Smolt mark-recapture studies		Adult salmon counts	
	Start	Finish	Start	Finish
1986			May 12	Sept 10
1987	April 28	June 16	May 18	Sept 8
1988	May 9	June 14	May 21	Aug 29
1989	May 9	June 15	May 20	Aug 28
1990	May 3	June 20	May 23	Aug 6
1991	May 3	June 16	May 26	Aug 18
1992	May 10	June 15	May 26	Aug 10
1993	May 9	June 14	May 28	July 31
1994	April 28	June 18	June 1	Sept 25
1995	May 2	June 8	May 30	Oct 16
1996	April 26	June 11	May 21	Sept 23
1997	May 15	June 15	May 29	Sept 4
1998	April 30	June 5	May 19	Sept 20
1999	April 21	June 8	May 16	Sept 13
2000	April 20	June 8	May 22	Aug 19

Table 2. Atlantic salmon landings (in numbers of fish) in the recreational fishery, 1974-1999, and in the native food fishery, 1986-2000, at Conne River, Newfoundland. Note that the recreational fishery was closed from 1993 - 1996 and again in 1998-1999, while the food fishery was closed from 1994 - 1996, and in 1998-1999.

	Recreational Fishery				Native Food Fishery			
	Effort	Salmon catch				Salmon catch		
Year	rod-days	Small	Large	Total	Quota	Small	Large	Total
1974	4033	1988	17	2005				
1975	3800	1903	17	1920				
1976	3894	1931	27	1958				
1977	3375	1665	5	1670				
1978	3122	1735	7	1742				
1979	2147	1010	0	1010				
1980	3512	2238	14	2252				
1981	5029	2691	2	2693				
1982	5268	3302	24	3326				
1983	6972	2192	21	2213				
1984	6709	2343	0	2343				
1985	5202	2729	0	2729				
1986	6038	2060	0	2060	1200	519	3	522
1987	4979	1598	0	1598	1200	18	0	18
1988	5504	1544	0	1544	1200	607	2	609
1989	4414	1036	0	1036	1200	381	1	382
1990	2740	767	0	767	1200	948*	11	11
1991	679	108	0	108	1200	281	3	284
1992	1499	329	0	329	1200	483	5	488
1993	0	0	0	0	500	417	3	420
1994	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0
1997		197	0	197	600	514	1	515
1998	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0
2000	0	730	0	730	0	0	0	0

* Total for 1990 does not include approximately 50 fish found dead and partially destroyed in traps.
Quotas of 100 and 330 small salmon were in effect for the recreational fishery in 1991 and 1992, respectively.
Initial food fishery allocation pending an inseason stock status review was for 600 small salmon.

Table 3a. Summary of biological characteristics for Atlantic salmon samples from Conne River, Newfoundland (SFA 11), 1986 - 2000.

Lifestage	Year	Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
		N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
Smolt	1987	271	144	16.5	106	196	271	29.1	9.9	11.5	73.8	271	3.32	0.54	2	5	270	77
	1988	328	147	15.7	102	201	328	32.3	10.4	12.4	78.8	328	3.41	0.51	3	5	327	73
	1989	288	152	21.3	98	238	286	35.0	14.0	9.8	123.2	288	3.25	0.53	2	5	288	79
	1990	271	148	21.2	100	253	271	30.5	13.1	10.3	122.8	271	3.29	0.49	2	5	271	74
	1991	246	153	19.9	104	244	246	33.5	13.6	12.6	112.5	246	3.19	0.44	2	5	245	66
	1992	169	149	15.6	116	189	169	30.1	8.9	14.9	59.2	169	3.28	0.51	2	5	169	71
	1993	246	149	16.5	114	196	246	31.6	10.3	15.7	71.7	246	3.26	0.45	3	5	246	67
	1994	208	148	15.1	116	190	208	29.6	8.3	16.0	59.2	208	3.20	0.41	2	4	208	74
	1995	249	143	15.2	103	179	249	28.6	8.3	10.3	50.6	249	3.31	0.51	2	5	249	73
	1996	243	151	16.0	102	224	243	32.9	10.2	16.3	93.8	243	3.16	0.47	2	5	243	73
	1997	380	148	16.2	114	233	380	30.9	11.0	14.9	105.8	380	3.21	0.45	2	5	380	75
	1998	282	147	14.8	110	233	282	30.8	9.4	12.4	106.0	282	3.23	0.48	2	5	282	71
	1999	257	148	15.3	110	188	257	32.1	9.2	13.5	62.8	257	3.19	0.41	2	4	257	74
	2000	258	152	16.5	111	226	258	34.4	12.1	15.0	95.6	258	3.27	0.50	2	5	258	74
TOTAL		3696	148	17.2	98	253	3696	31.6	11.0	9.8	123.2	3696	3.26	0.49	2	5	3683	73
1 SW	1986	357	508	23.0	440	570	357	1461	220.4	900	2900	357	3.38	0.57	2	5	358	76
	1987	398	509	23.2	430	580	398	1478	248.2	800	2800	398	3.22	0.48	2	5	352	79
	1988	267	506	26.1	440	600	267	1352	226.5	1000	2200	267	3.14	0.42	2	4	261	80
	1989	140	512	23.3	460	580	140	1411	201.7	1000	2000	140	3.18	0.50	2	5	135	79
	1990	174	508	23.4	449	575	142	1454	184.4	1100	2000	174	3.27	0.52	2	5	141	81
	1991	38	514	22.8	455	552	34	1362	172.4	1000	1700	39	3.18	0.39	3	4	33	70
	1992	77	505	22.4	453	580	36	1363	276.1	900	2000	77	3.18	0.53	2	5	43	79
	1993	39	513	30.8	475	620	0					39	3.05	0.32	2	4	0	
	1994 *	73	510	25.8	405	580	89	1272	193.9	800	1800	73	3.12	0.44	1	4	71	75
	1995 *	111	486	24.8	433	573	107	1144	184.4	800	1700	111	3.14	0.42	2	5	105	77
	1996	72	518	21.8	475	573	19	1523	219.1	1160	1920	72	3.22	0.51	2	5	2	100
	1997	163	514	22.1	460	590	39	1467	321.5	700	2000	163	3.24	0.48	2	5	39	82
	1998	135	502	22.3	420	580	0					135	3.08	0.42	2	4	0	
	1999	112	513	21.6	450	580	1	2300		2300	2300	112	3.15	0.43	2	4	1	100
	2000	193	517	23.4	460	580	110	1644	211.5	1100	2200	193	3.18	0.45	2	4	98	84
TOTAL		2350	509	24.0	405	620	1719	1423	247.0	800	2900	2350	3.21	0.49	1	5	1637	78

* Samples of 1SW salmon in 1994 and 1995 were obtained from fish held for brood stock. Thus fish were sampled in September in each of these years.

Table 3a. (Continued) Summary of biological characteristics for Atlantic salmon samples from Conne River, Newfoundland (SFA 11), 1986 - 2000.

Lifestage	Year	Fork length (mm)					Whole weight (g)					River age (y)					Sex Ratio	
		N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max	N	% female
2 SW	1986	1	630				1	2600				1	3.00				1	100
	1989	2	685	21.2	650	680	1	2700				2	3.50	0.71	3	4	1	100
	1992	1	650				1	2700				1	4.00				0	
	1994	1	700				0					1	3.00				0	
	1995	2	735	49.5	700	770	0					2	3.00	0.00	3	3	0	
	1996	2	665	14.1	655	675	0					2	2.50	0.71	2	3	0	
	1997	1	740				0					1	3.00				0	
	2000	1	665									1	3.00				0	
TOTAL		11	683	41.9	630	770	3	2667	57.7	2600	2700	11	3.09	0.54	2	4	2	100
Consecutive Spawning Grilse																		
	1986	1	560				1	1800				1	3.00				1	100
	1987	6	528	29.4	485	576	6	1575	351.6	1070	2100	6	3.17	0.75	2	4	5	100
	1988	5	556	24.1	530	590	5	1640	280.8	1500	2100	5	2.80	0.84	2	4	5	40
	1989	6	575	23.5	550	610	6	1767	233.8	1500	2000	6	3.00	0.00	3	3	6	50
	1990	3	564	51.4	505	601	0					3	3.33	0.58	3	4	0	
	1991	4	586	49.9	548	659	1	1400				4	3.50	0.58	3	4	1	100
	1992	8	581	43.6	530	660	0					8	3.50	0.53	3	4	0	
	1993	3	617	58.9	570	680	0					3	2.67	1.15	2	4	0	
	1994	15	564	36.1	510	640	14	1714	455.5	1200	2900	15	3.20	0.56	2	4	15	73
	1995	2	547	3.5	544	549	2	1500	141.4	1400	1600	2	3.00	0.00	3	3	2	100
	1996	19	572	60.8	505	795	0					19	3.16	0.37	3	4	2	50
	1997	52	582	37.0	510	685	0					52	3.21	0.50	2	4	0	
	1998	29	591	45.8	490	700	0					29	3.28	0.45	3	4	0	
	1999	33	587	59.5	480	730	2	2450	70.7	2400	2500	33	3.27	0.45	3	4	1	100
	2000	14	606	65.4	540	775	4	1875	287.2	1500	2200	14	3.21	0.58	3	5	4	100
TOTAL		200	581	24.0	480	795	41	1729	378.3	1070	2900	200	3.22	0.51	2	5	42	74
Alternate Spawning Grilse																		
	1986	1	600				1	2400				1	3.00				1	100
	1989	13	683	18.9	650	710	2	3350	212.1	3200	3500	13	3.08	0.28	3	4	2	100
	1991	2	700	29.0	679	720	0					2	3.50	0.71	3	4	0	
	1992	8	682	44.4	630	770	0					8	2.88	0.36	2	3	1	100
	1993	6	675	35.1	640	710	0					6	3.33	0.52	3	4	0	
	1994	3	703	45.1	660	750	0					3	3.00	0.00	3	3	0	
	1995	5	730	29.2	710	780	0					5	3.00	0.00	3	3	0	
	1996	4	710	21.2	695	740	0					4	3.25	0.50	3	4	0	
	1997	19	702	30.9	655	780	0					19	3.21	0.42	3	4	0	
	1998	27	691	32.1	625	760	0					27	3.07	0.27	3	4	0	
	1999	29	707	30.2	660	760	0					29	3.21	0.41	3	4	0	
	2000	13	695	38.7	645	760	0					13	3.00	0.41	2	4	0	
TOTAL		130	696	33.9	600	780	3	3033	568.6	2400	3500	130	3.12	0.37	2	4	4	100

Table 3b. Summary of biological characteristic information by life-history groups for small and large fish with corresponding notation for Conne River Atlantic salmon, 1996 - 2000.

Life-history group	Notation		Notation		Fork length (mm)					Whole weight (g)				
			N	Percent	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
Small salmon (< 630 mm for length; N = 2521)														
Virgin grilse	1.1		1	0.04	1	531				1	1300			
	2.1		65	2.58	65	502	24.5	440	550	46	1365	249.6	600	1900
	3.1		1736	68.86	1736	508	23.7	405	610	1248	1416	242.6	700	2600
	4.1		533	21.14	533	511	24.4	420	620	411	1450	258.8	800	2900
	5.1		15	0.60	15	522	26.8	490	590	13	1460	229.8	1000	1800
Consecutive spawning grilse	2.1.SM		5	0.20	5	552	20.5	520	570	3	1633	152.8	1500	1800
	3.1.SM		100	3.97	100	562	30.6	490	625	27	1700	301.3	1300	2400
	3.1.SM.SM		21	0.83	21	596	22.7	560	625	3	2100	360.6	1800	2500
	4.1.SM		37	1.47	37	557	30	480	610	6	1428	242.5	1070	1700
	4.1.SM.SM		6	0.24	6	583	28.1	550	625	1	2300			
Alternate spawning grilse	3.1.SM.1		2	0.08	2	613	17.7	600	625	1	2400			
Large salmon (>= 630 mm for length; N = 170)														
Virgin 2SW	2.2		1	0.59	1	675								
	3.2		8	4.71	8	683	49.6	630	770	3	2667	57.7	2600	2700
	4.2		2	1.18	2	690	14.1	680	700					
Consecutive spawning large	2.1.SM.SM		2	1.18	2	670	14.1	660	680					
	2.1.SM.SM.SM.SM		1	0.59	1	640								
	3.1.SM		1	0.59	1	630								
	3.1.SM.SM		13	7.65	13	686	54.5	630	795					
	3.1.SM.SM.SM		5	2.94	5	683	34.2	640	730					
	3.1.SM.SM.SM.SM		2	1.18	2	690	0.0	690	690					
	4.1.SM.SM		5	2.94	5	650	10.0	640	660					
	4.1.SM.SM.SM		1	0.59	1	650								
	5.1.SM.SM.SM		1	0.59	1	640								
Alternate spawning large	2.1.SM.1		2	1.18	2	655	35.4	630	680					
	3.1.SM.1		105	61.76	105	697	29.9	640	760	2	3350	212.1	3200	3500
	3.1.SM.SM.1	*	2	1.18	2	730	42.4	700	760					
	3.1.SM.SM.SM.1	*	1	0.59	1	680								
	4.1.SM.1		18	10.59	18	704	37.9	640	790					

* These fish originally spawned consecutively, then remained at sea for a full year to return as an alternate spawner. These cases all occurred in salmon that returned in 1998.

Table 4. Estimated numbers of small and large Conne River Atlantic salmon partitioned by life stage, and the percentage of 1SW small salmon that survive to spawn in year i+1 as a small consecutive spawner. The last column includes the contribution of small or large salmon from year i - 2 only, in deriving the estimated survival of repeat spawners. Bracketed value for 1999 is preliminary pending consecutive and alternate spawners in 2001.

	Small salmon						Large salmon						
			Previous spawners						Previous spawners				
			Consecutive		Alternate	Survival of 1SW fish to consecutive spawners (%)			Consecutive	Alternate			% Survival of 1SW salmon to consecutive or alternate spawners (small and large salmon to year i - 2 only)
Year	Total	1SW	(from year i - 1)	(from year i - 2)	(from year i - 2)	in year i+1	Total	2SW	(from year i - 2)	(from year i - 2)	(from year i - 3)	Other	
1986	8302	8256	0	23	23	1.83	412	27	48	245	53	39	5.45
1987	10155	10004	151	0	0	1.40	516	33	61	307	67	48	3.68
1988	7627	7487	140	0	0	2.72	420	27	49	250	54	40	6.26
1989	4988	4784	204	0	0	1.91	320	21	38	190	41	30	4.24
1990	5368	5277	91	0	0	3.77	372	24	44	221	48	35	6.86
1991	2411	2184	199	48	0	9.66	89	6	10	53	12	8	15.39
1992	2523	2264	209	50	0	9.69	159	10	19	94	21	15	14.36
1993	2703	2426	224	53	0	5.23	100	6	12	59	13	10	8.45
1994	1533	1376	127	30	0	4.51	100	6	12	59	13	10	13.74
1995	3502	3440	62	0	0	24.16	110	7	13	65	14	11	32.86
1996	4154	3323	831	0	0	16.49	179	12	21	108	23	17	25.04
1997	3200	2484	548	168	0	14.09	165	12	22	110	24	17	24.46
1998	2831	2489	350	74	18	12.66	295	19	35	175	38	28	20.85
1999	2358	1956	315	87	0	9.20	241	16	28	143	31	23	(9.20)
2000	5177	4948	180	51	0		216	14	25	128	28	21	

* example of survival calculation from 8256 1SW salmon in 1986 that would include large salmon:

151 consecutive spawners from 1987 + 48 (large) consecutive spawners from 1988 + 250 (large) alternate spawners

from 1988: = 469/8256 * 100 = 5.45%. There were no small consecutive spawners in year i-2 in this example.

1SW data for 1986 have been adjusted for the wild-aquacultured salmon that returned that year (4440 - 286 = 4154 small salmon)

For large salmon, the average breakdown over all years (1986-1999) has been used to apportion fish into respective life history classes, of which only the most common are illustrated here, with other combinations listed as 'other'.

Table 5. Mean number of eggs per female, length, weight data, and relative fecundity of Conne River Atlantic salmon.

Year		N	Number of eggs per female				Length (cm)				Weight (kg)				Relative Fecundity	
			Mean	STD	Min	Max	Mean	STD	Min	Max	Mean	STD	Min	Max	No. of eggs per cm	No. of eggs per kg
1987	*	30	2430	403	1796	3454	50.7	2.37	46.0	56.0	1.26	0.17	1.02	1.74	47.8	1907
1986		102	3494	662	1450	5590	50.9	2.37	45.0	56.0	1.48	0.23	1.00	2.90	68.7	2367
1987		136	3424	635	1287	5476	51.1	2.36	42.0	57.6	1.45	0.25	1.00	2.60	67.0	2364
1988		85	3196	568	2111	5054	50.2	2.50	46.0	60.0	1.35	0.24	1.00	2.20	63.7	2366
1990		93	2245	575	703	3544	51.1	2.09	46.0	57.0	1.45	0.18	1.10	2.00	44.0	1545
1991		22	2772	1241	595	5010	51.7	2.01	47.0	55.2	1.35	0.15	1.00	1.60	53.6	2048
1992		21	1768	498	1009	2545	50.6	2.15	45.3	55.2	1.36	0.25	0.90	1.90	35.0	1278
1997		33	3527	459	2929	5158	51.6	2.29	46.0	57.5	1.45	0.33	0.70	2.00	70.3	2504
2000		44	3591	678	2383	4768	52.8	2.10	47.5	57.0	1.69	0.22	1.30	2.10	68.0	2123
Years Combined	**	536	3131	843	595	5590	51.1	2.37	42.0	60.0	1.45	0.25	0.70	2.90	61.3	2155

* These 1987 data were obtained from ripe salmon sampled at the end of October. For other years, samples were obtained primarily in June and July.

** Information from years combined does not include data from ripe salmon sampled in 1987.

Table 6. Total estimated returns of small salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-2000.

	Year														
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Returns															
* Food Fishery (estuary)	766	451	508	317	831	234	403	347	0	0	0	428	0	0	0
Angling below fence				180	213	70	137	0	0	0	0	95	0	0	420
Mortalities below fence	21	17	3	2	3	2	0	1	0	2	4	1	0	1	5
Count at fence	7515	9287	7118	4469	4321	2086	1973	2355	1533	3500	4436	2676	2931	2357	4708
Estimated count		400				19	10								44
Total Returns	8302	10155	7627	4968	5368	2411	2523	2703	1533	3502	4440	3200	2931	2358	5177
1 - Released at fence	7515	9687	7118	4469	4321	2105	1983	2355	1533	3500	4436	2676	2931	2357	4752
Removals and mortalities															
Mortalities above fence/or in trap	27	21	7	4	2	5	8	2	5	7	9	5	5	8	11
Angling above fence	2080	1598	1544	856	554	38	192	0	0	0	0	102	0	0	310
Brood stock removal	0	245	0	0	0	0	0	0	93	117	25	0	0	0	0
Farmed salmon removed	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Hook and release mortalities												8			0
2 - Total	2087	1864	1551	860	556	43	200	2	98	124	34	118	5	8	321
Spawning escapement															
(1) - (2)	5428	7823	5567	3609	3765	2062	1783	2353	1435	3376	4402	2558	2926	2349	4431
Egg deposition															
In millions of eggs	9.90	15.03	10.61	6.92	7.48	3.72	3.23	4.43	2.78	6.00	8.25	4.81	5.51	4.42	8.33
% of Management Target met	127	193	136	89	96	48	41	57	36	77	106	62	71	57	107
% of Conservation egg requirement met	228	346	245	160	172	86	75	102	64	138	190	111	127	102	192

* Food fishery includes fish caught in the estuary during tagging studies in 1986 and 1987. Proportions of Conne River origin salmon in 1986 and 1987 were 0.782 (N = 867) and 0.914 (N = 493), respectively. For remaining years, the weighted mean (0.833) was used.

Notes: Results for 1994 are for wild fish only, and do NOT include any impact of the egg deposition 'equivalency' from fry reared in 1994-95. Count of small salmon in 1996 includes 266 fish that were derived from the release of the wild smolt aquaculture experiment.

Table 7. Total estimated returns of large salmon to Conne River, Newfoundland, with a summary of mortalities and removals and estimated spawning escapement, 1986-2000. Total estimated egg deposition from small and large salmon are also indicated along with the combined estimate of the percentage of the Management Target or Conservation egg requirement met.

	Year														
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Returns															
* Food Fishery (estuary)	14	18	2	1	11	2	4	2	0	0	0	1	0	0	0
Angling below fence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mortalities below fence	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Count at fence	397	498	418	319	361	87	154	98	100	110	179	184	284	241	216
Estimated count															
Total Returns	412	516	420	320	372	89	159	100	100	110	179	185	285	241	216
1 - Released at fence	397	498	418	319	361	87	154	98	100	110	179	184	284	241	216
Removals and mortalities															
Mortalities above fence/or in trap	1	0	0	0	0	0	1	1	0	2	0	0	0	1	0
Angling above fence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brood stock removal		10							1	0	0	0	0	0	0
Farmed salmon removed												2			
Hook and release mortalities															
2 - Total	1	10	0	0	0	0	1	1	1	2	0	2	0	1	0
Spawning escapement															
(1) - (2)	396	488	418	319	361	87	163	97	99	108	179	182	284	240	216
Egg deposition															
In millions of eggs	1.48	2.07	1.77	1.09	1.23	0.30	0.52	0.33	0.34	0.37	0.61	0.62	1.01	0.88	0.77
% of Management Target met	19	27	23	14	16	4	7	4	4	5	8	8	13	11	10
% of Conservation egg requirement met	34	48	41	25	28	7	12	8	8	9	14	14	23	20	18
Total egg deposition - small and large salmon	11.38	17.10	12.38	8.01	8.71	4.01	3.76	4.76	3.12	6.37	8.88	5.44	8.51	5.28	9.10
Egg deposition per unit fluvial habitat	864	1297	939	608	661	304	285	361	236	483	672	413	494	401	690
Total % Management Target met	146	219	159	103	112	51	48	61	40	82	114	70	84	68	117
Total % Conservation requirement met	262	394	285	185	201	93	87	110	72	147	204	125	150	122	210

* Food fishery includes fish caught in the estuary during tagging studies in 1986 and 1987. Proportions of Conne River origin salmon in 1986 and 1987 were 0.702 (N = 987) and 0.914 (N = 493), respectively. For remaining years, the weighted mean (0.833) was used.

One unit of fluvial habitat = 100 m².
Conne River has an estimated 13,100 units of accessible fluvial habitat.

Table 8. Estimates of Atlantic salmon smolts from Conne River, 1987 - 2000, along with subsequent survival to both small salmon in year i + 1, and to 1SW salmon (repeat spawning fish omitted).

	Number of smolts			Population estimate			Survival		
	Upper site	Lower site					% survival		% survival
Year (i)	Tagged & released	Total number Captured	Tag Recoveries	N	Confidence interval	Coefficient of variation %	to small salmon year i + 1	range	to 1SW salmon year i + 1
1987	4975	14314	990	74585	67597 - 81573	5.1	10.2	9.3 - 11.3	10.04
1988	3235	19515	1054	65692	59862 - 71522	4.8	7.6	6.9 - 8.3	7.25
1989	2699	16928	604	73724	66598 - 80850	5.1	7.3	6.7 - 8.1	7.16
1990	3719	13281	945	56943	52315 - 61571	4.4	4.2	3.9 - 4.6	3.80
1991	3753	9581	398	74645	62033 - 87527	9.0	3.4	2.9 - 4.1	3.03
1992	3758	10229	529	68206	61334 - 75052	5.4	4.0	3.6 - 4.4	3.56
1993	2456	15992	735	55765	51666 - 59864	3.9	2.7	2.6 - 3.0	2.47
1994	2366	11875	479	60762	53759 - 67765	6.2	5.8	5.2 - 6.5	5.66
1995	2558	12260	545	62749*	55300 - 70197	6.3	7.2	6.4 - 8.3	5.76
1996	3373	14575	499	94068	79867 - 108309	8.0	3.4	3.0 - 4.0	2.64
1997	3715	18290	662	100963	92812 - 109154	8.4	2.9	2.7 - 3.2	2.46
1998	2952	8636	387	69841	60617 - 79064	13.8	3.4	3.0 - 3.9	2.80
1999	2179	7545	258	63658	53305 - 74011	16.8	8.1	7.0 - 9.7	7.77
2000	3361	6168	400	60777	51783 - 69771	8.1	-	-	-

* Of these fish, 5016 smolt were transferred to sea cage holding facilities at Roti Bay.

Table 9. Occurrence of escaped farmed Atlantic salmon at Conne River, Newfoundland, 1993 - 2000.

Year	Number of specimens examined	Number of farmed salmon identified	Percentage farmed origin	Life Stage	Location	Method
1993	1	1	100	Adult	Food Fishery	Scale identification
1994	94	2	2.1	Adult	Conne River	Scale identification
		12		Smolt	Conne River	Scale identification and colouration
1995	120	0	0	Adult	Conne River	Scale identification
1996	97	0	0	Adult	Conne River	Scale identification
		59		Smolt	Conne River	Scale identification and colouration
1997	430	8	1.9	Adult	Conne River	External chacteristics
	235	2	0.9	Adult	Conne River	Scale identification
	480	4	0.8	Adult	Food Fishery	Scale identification
1998	191	2	1.0	Adult	Conne River	Scale identification
1999	174	1	0.6	Adult	Conne River	Scale identification
2000	221	5	2.3	Adult	Conne River	Scale identification

Table 10. Summary of rainbow trout occurrences and captures at Conne River, 1999 - 2000, with corresponding size data where available. Information from past years has been summarized in previous research assessment documents (Dempson et al. 1999, 2000). for completeness.

Year	Date	Location/gear	Length (mm)
1999	April 23	Snorkling observation (N = 5)	350 - 550
	May 6	Angled in lower river (N = 3)	
	May 6	Angled in lower river	485
	May 6	Angled in lower river	473
	May 6	Angled in lower river	500
	May 8	Angled in lower river (N = 4)	
	May 11	Angled in lower river (N = 8)	350 - 550
	May 15	Snorkling observation (N = 15)	300 - 500
	May 18	Upstream trap	385
	May 18	Upstream trap	490
	June 14	Upstream trap	450
	June 16	Snorkling observation (N = 25)	200 - 400
	June 22	Snorkling observation (N = 20)	200 - 400
	June 27	Snorkling observation (N = 15)	200 - 400
	July 1	Snorkling observation (N = 15)	200 - 450
	July 17	Snorkling observation (N = 8)	300 - 500
	July 18	Snorkling observation (N = 1)	~ 300
	Aug 12	Snorkling observation (N = 12)	300 - 500
2000	April 23	Snorkling observation (N = 2)	400 - 500
	April 23	Angled in lower river (N = 13)	350 - 500
	May 23	Snorkling observation (N = 8)	350 - 550
	June 11	Angled in lower river (N = 1)	520
	June 12	Angled in lower river (N = 1)	490
	July 5	Snorkling observation (N = 0)	
	July 23	Snorkling observation (N = 0)	

Rainbow trout captured in Conne River, March 28 - 30, 2000. All fish were caught by angling in the lower section of the river below Goodyears and Dashwood Steady. Gross examination of stomach contents are provided.

Length (mm)	Whole weight (kg)	Sex	Stomach Contents
560	2.6	-	5 Caddis larvae
450	1.1	-	detritus
380	0.6	-	detritus
490	1.6	-	detritus
520	2.1	-	8 small stones
400	0.7	-	detritus
370	0.7	-	detritus
410	0.9	-	detritus
440	1.0	-	12 small stones

Table 11. Estimated total number of migrating smolts in each age group by year, Conne River, Newfoundland, 1987 - 2000, along with the corresponding number of smolts produced by year-class relative to the year eggs were spawned. Lower chart indicates the percentage of smolts at each river age.

Year	River age (y) 2	3	4	5	Total	Year Class (eggs)	Smolt Production
1987	1417	49002	22823	1343	74585	1984	59606
1988	0	39875	25029	788	65692	1985	69022
1989	2285	52197	17915	1327	73724	1986	57499
1990	399	39917	16228	399	56943	1987	78211
1991	896	59492	13660	597	74645	1988	65237
1992	409	50065	16097	1637	68208	1989	55008
1993	0	41266	14276	223	55765	1990	68021
1994	304	47880	12578	0	60762	1991	58776
1995	502	42858	18636	753	62749	1992	95707
1996	2729	75553	14301	1505	94088	1993	98581
1997	808	79978	18884	1313	100983	1994	66139
1998	978	52241	15854	768	69841	1995	68491 *
1999	255	50799	12604	0	63658		
2000	1155	42422	16714	486	60777		

* 1995 year class complete to river age 4 smolts in 2000

Year	Percent in each age group 2	3	4	5	Number of samples
1987	1.9	65.7	30.6	1.8	271
1988	0.0	60.7	38.1	1.2	328
1989	3.1	70.8	24.3	1.8	288
1990	0.7	70.1	28.5	0.7	271
1991	1.2	79.7	18.3	0.8	246
1992	0.5	73.4	23.7	2.4	189
1993	0.0	74.0	25.6	0.4	246
1994	0.5	78.8	20.7	0.0	208
1995	0.8	68.3	29.7	1.2	249
1996	2.9	80.3	15.2	1.6	243
1997	0.8	79.2	18.7	1.3	380
1998	1.4	74.8	22.7	1.1	282
1999	0.4	79.8	19.8	0.0	257
2000	1.9	69.8	27.5	0.8	258
Average (1987 - 2000)	1.2	73	24.7	1.1	3696

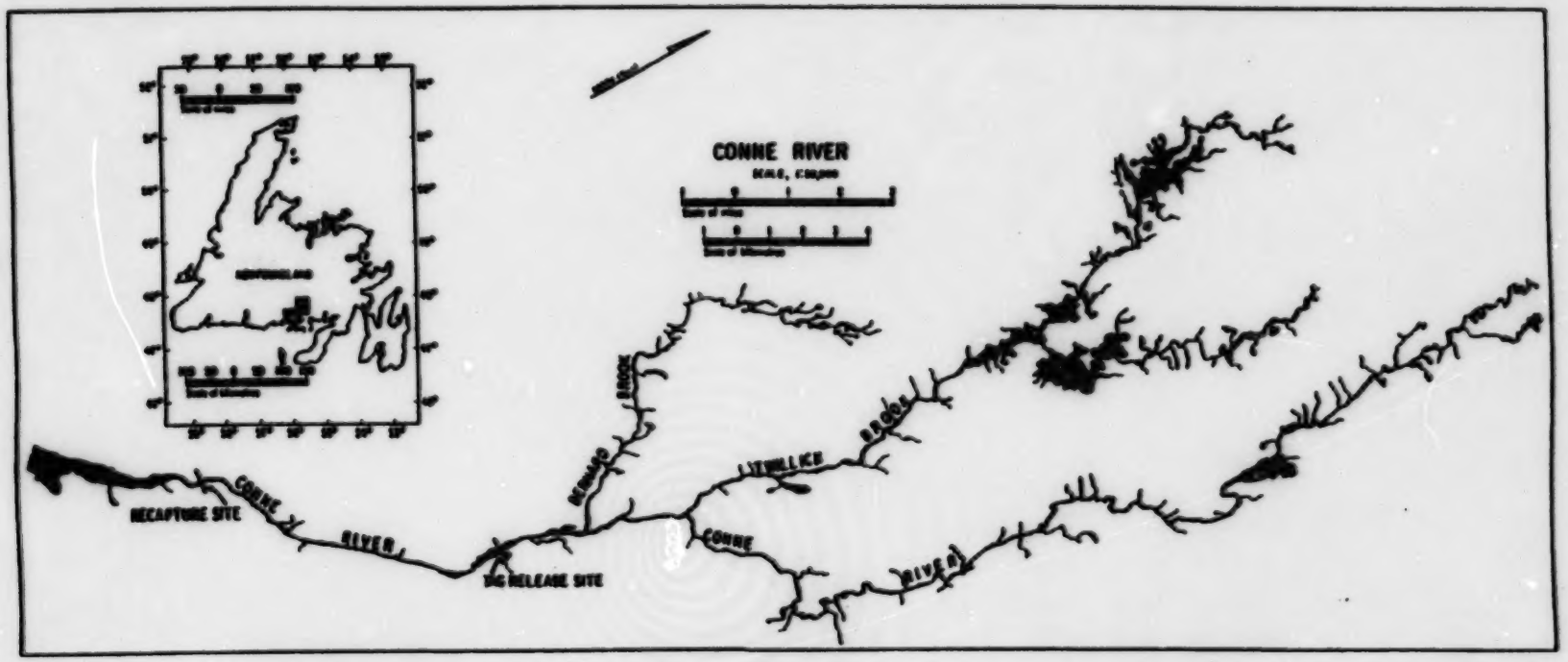


Fig. 1. Conne River, Newfoundland, SFA 11, illustrating the location of the fish counting fences used for the smolt mark-recapture survey. The recapture site is also the location of the upstream adult fish counting facility.

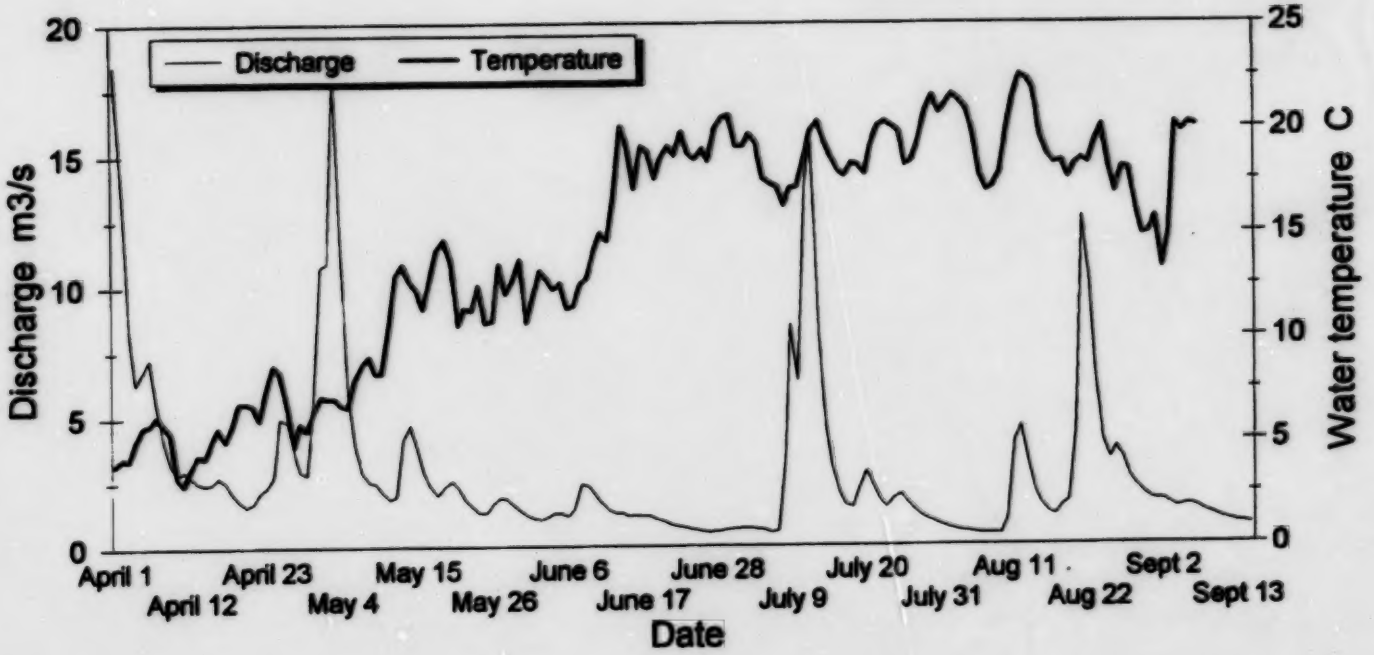


Figure 2. Discharge and temperature (April 1 - Sept. 14) profile at Conne River, Newfoundland, 2000. Discharge data from the Environment Canada monitoring station located below Conne Pond. Temperature data from a Hugrun thermograph located at the lower (adult) fish counting fence site.

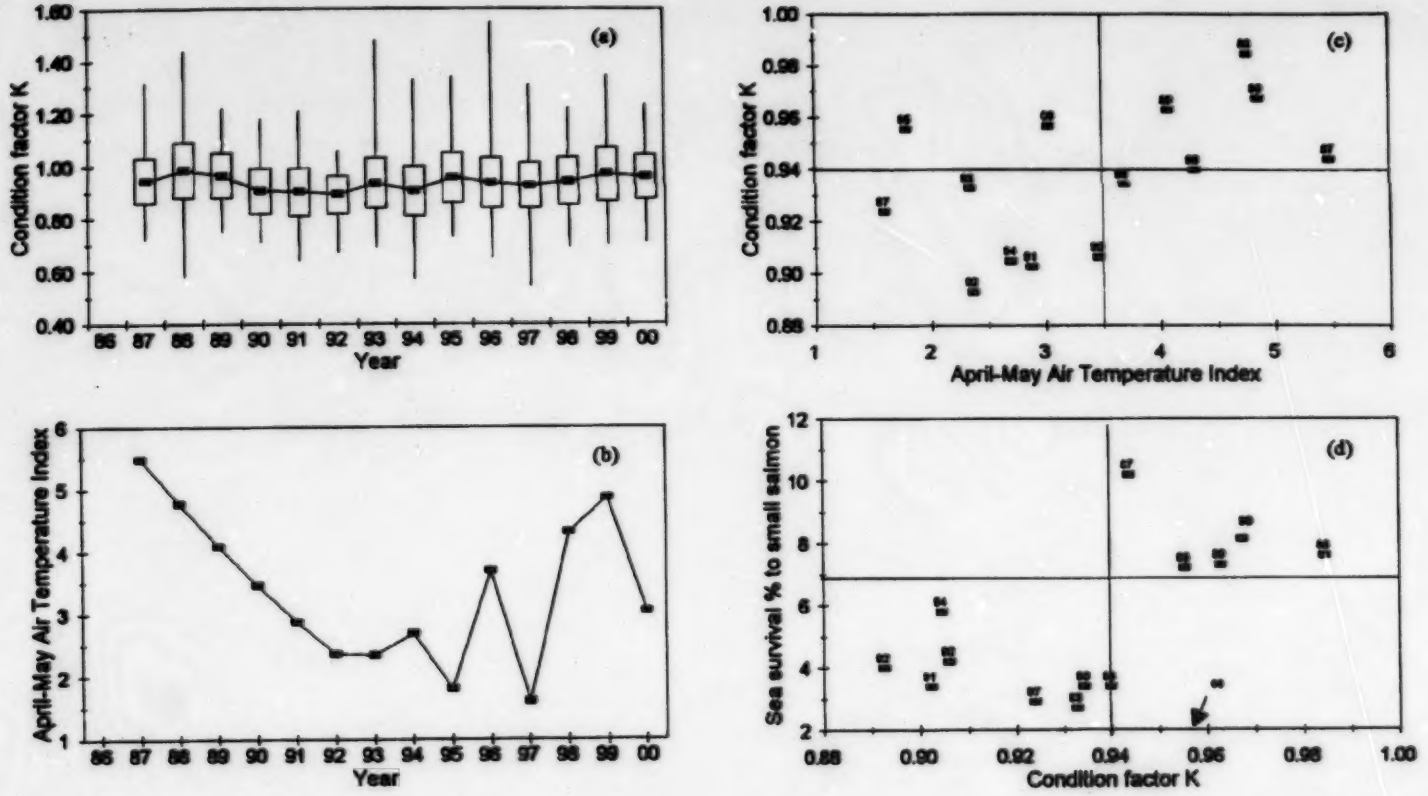


Figure 3. Trends in (a) Conne River smolt condition and (b) the April-May air temperature index over years; (c) smolt condition versus the air temperature index, and (d) sea survival (%) of small salmon versus smolt condition. Years shown refer to the year of smolt migration. In panel (d), the arrow indicates the 2000 smolt condition. In plot (a), vertical lines represent the minimum and maximum condition, the rectangle denotes one standard deviation about the mean which is the point within the rectangle.

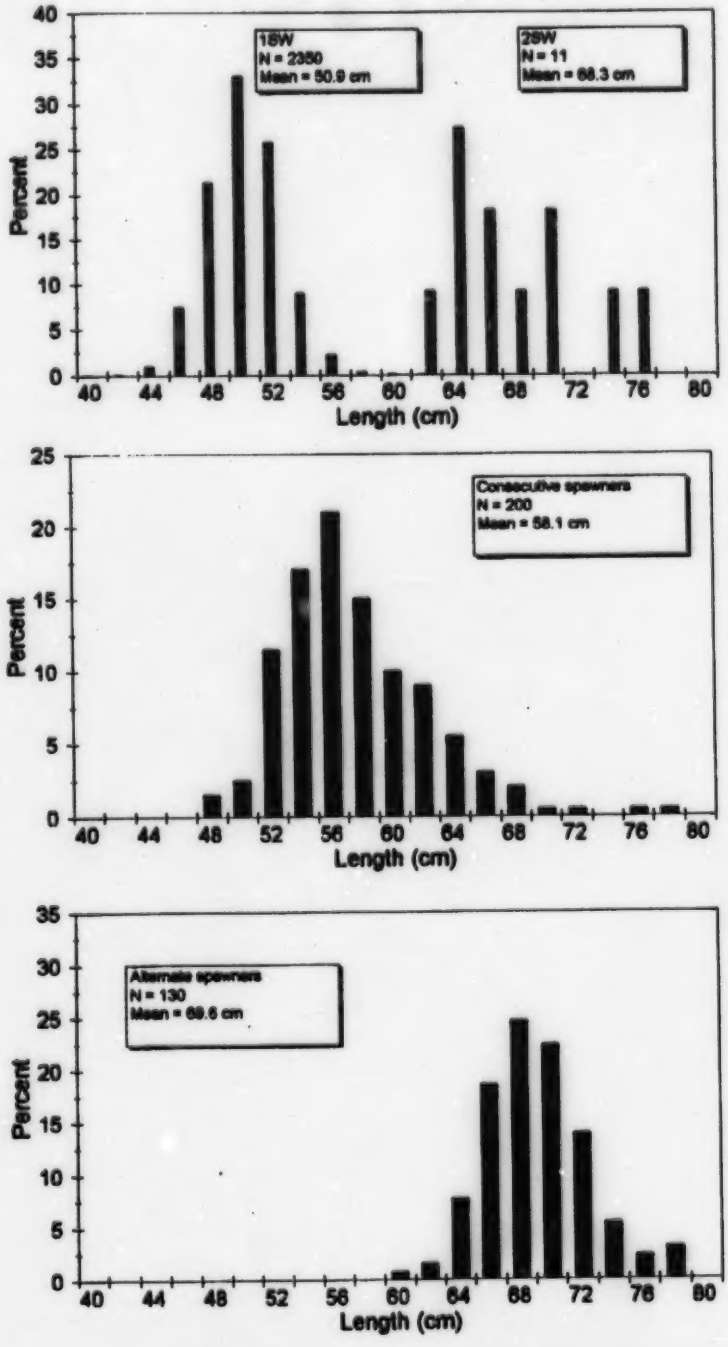


Figure 4. Length-frequency distribution of 1SW, 2SW, consecutive and alternate spawners, all years (1986 - 2000) combined, at Conne River, Newfoundland.

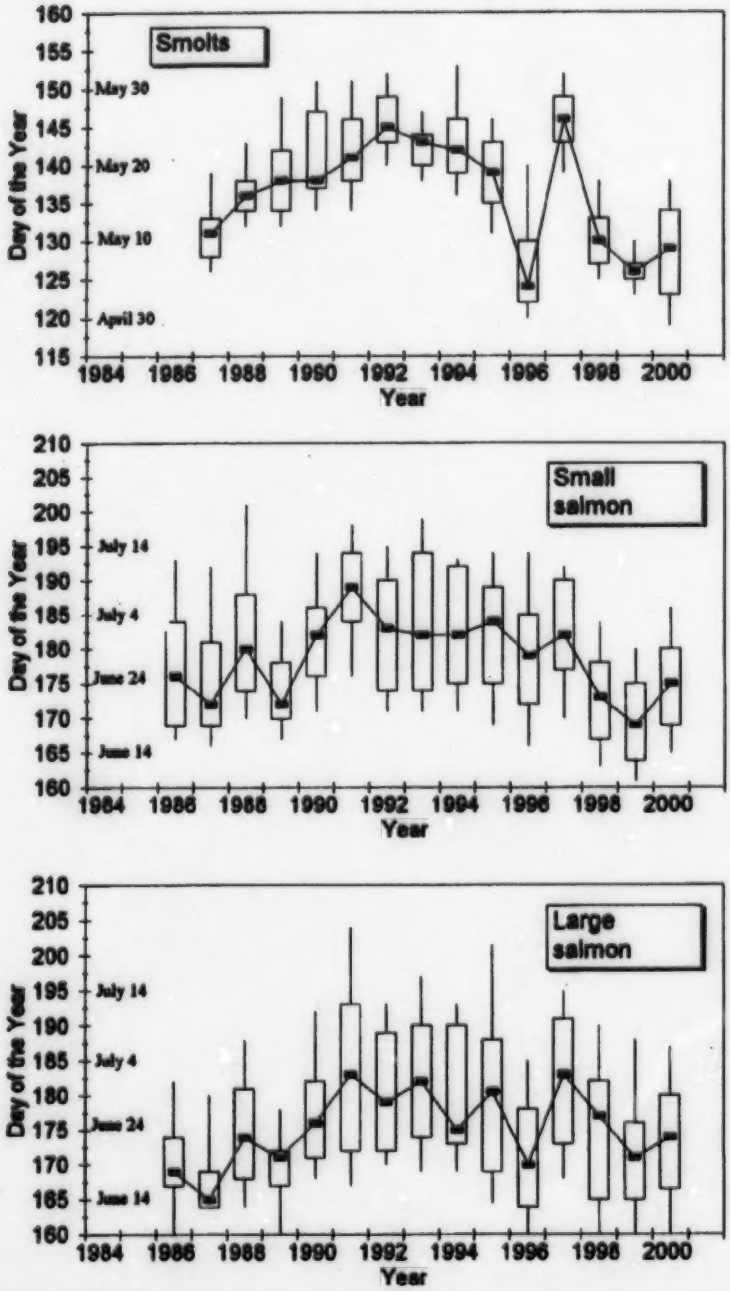


Figure 5. Annual variation in run timing at Conne River, Newfoundland, for Atlantic salmon smolts and returning small and large salmon. Vertical lines represent the 10th and 90th percentiles of the day of the year of migration, the rectangle is the 25th and 75th percentiles, and the marker within the rectangle is the median run timing value.

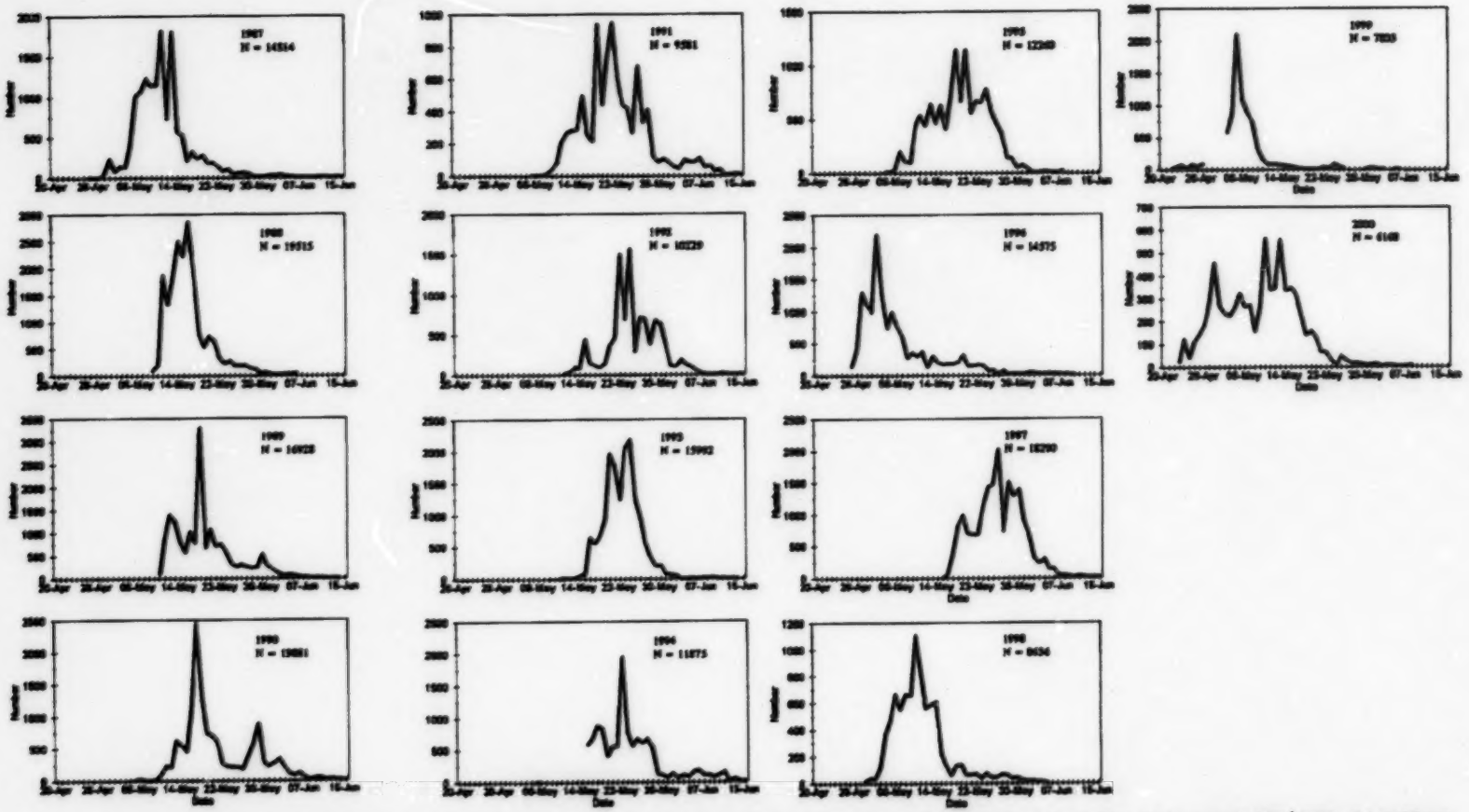


Figure 6. Numbers of Atlantic salmon smolts counted by day up to June 15 each year at the downstream fish counting fence trap at Conne River, Newfoundland, 1987 - 2000. N = total fence count of smolt for the season. Note that the total smolt population is estimated by mark-recapture.

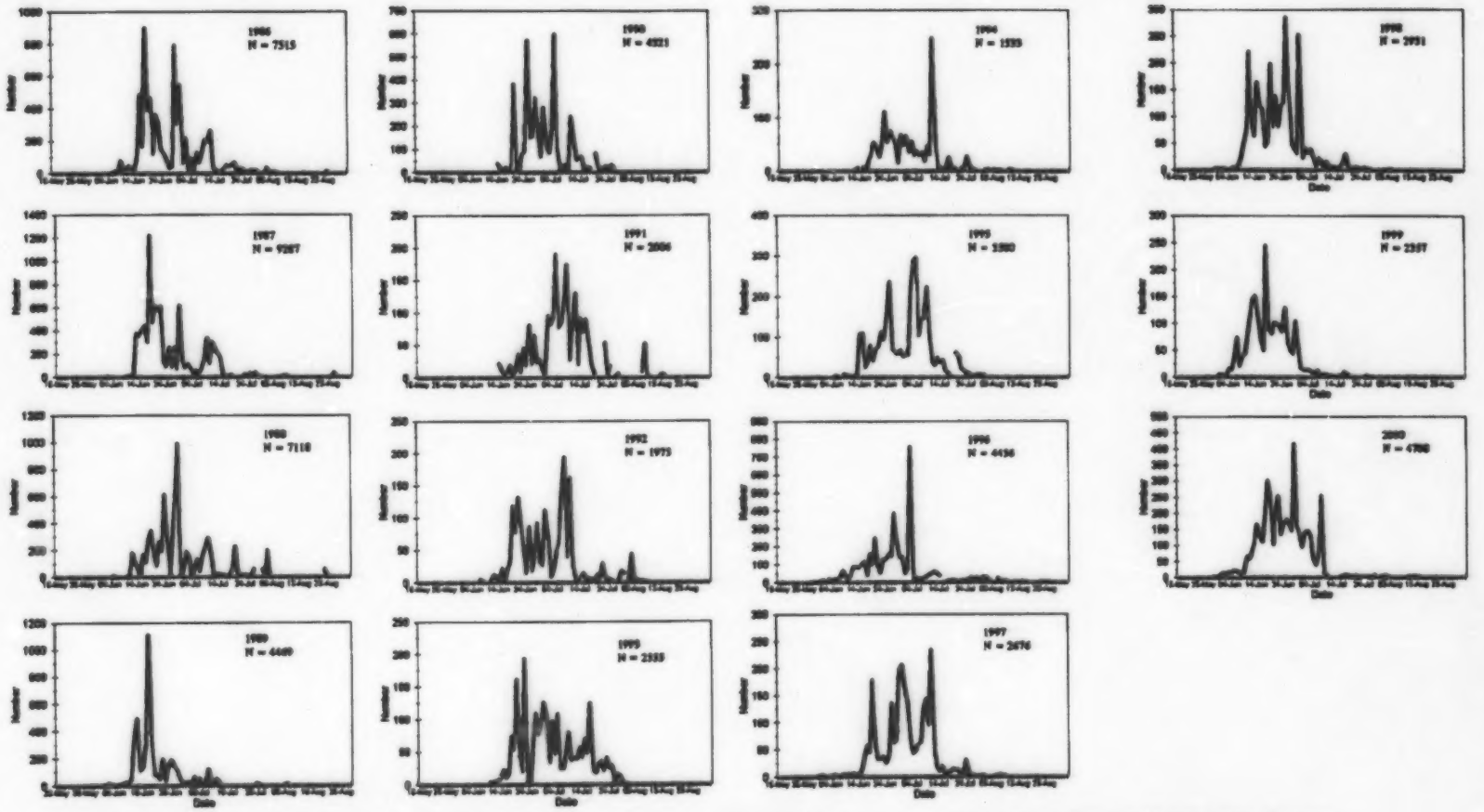


Figure 7. Numbers of small Atlantic salmon counted by day up to August 31 each year at the upstream fish counting fence at Conne River, Newfoundland, 1988 - 2000. N = total fence count of small salmon for the entire season.

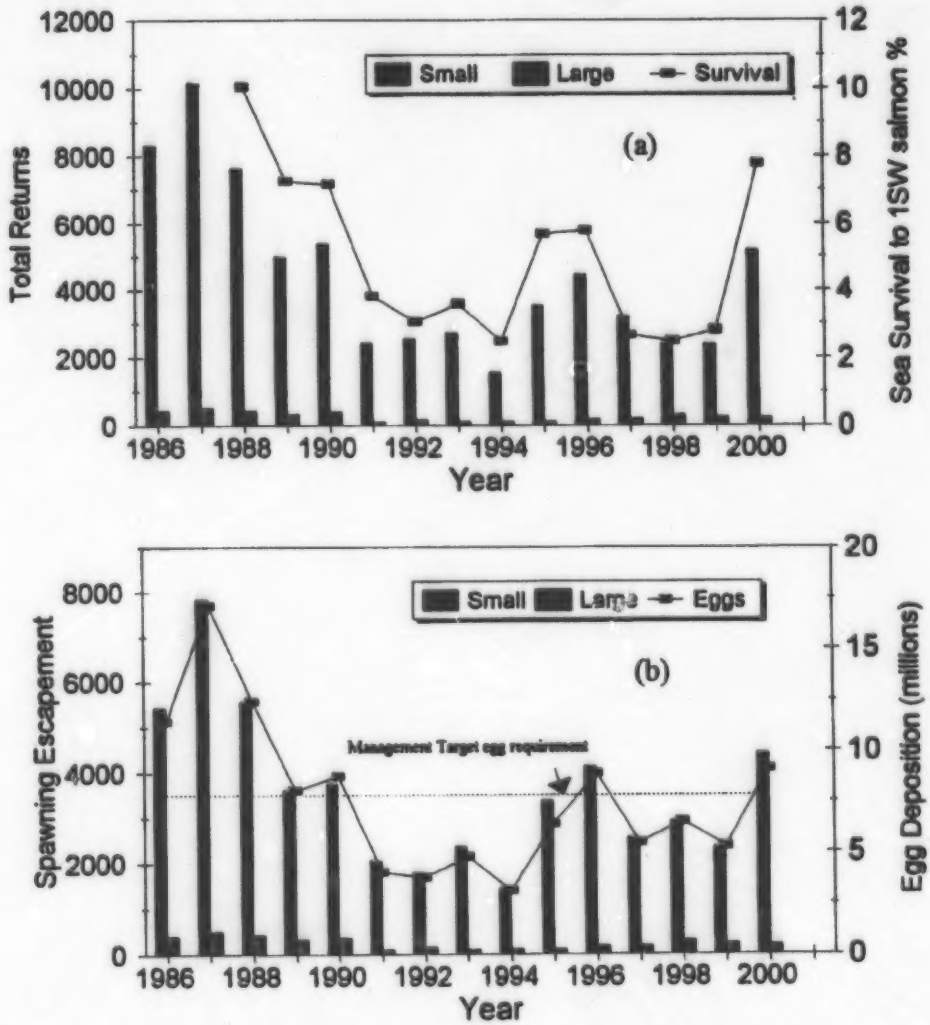


Figure 8. Total returns of small and large Atlantic salmon to Conne River, Newfoundland along with estimated sea survival from smolts to 1SW salmon (a). Survival estimates correspond to the year of adult return. Lower panel (b) illustrates the trend in spawning escapments and estimated egg deposition. The dashed horizontal line represents the current Management Target egg requirement.

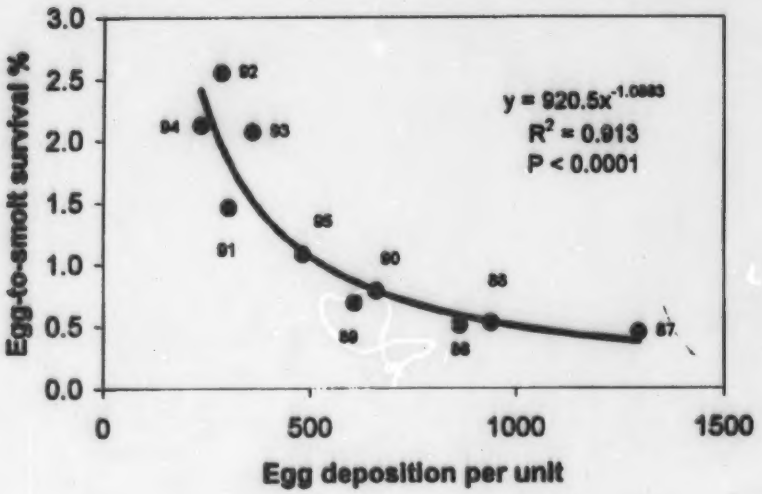


Fig. 9. Relationship between egg-to-smolt survival and the egg deposition rate per unit of fluvial habitat for Conne River, Newfoundland. Year shown refers to year of egg deposition

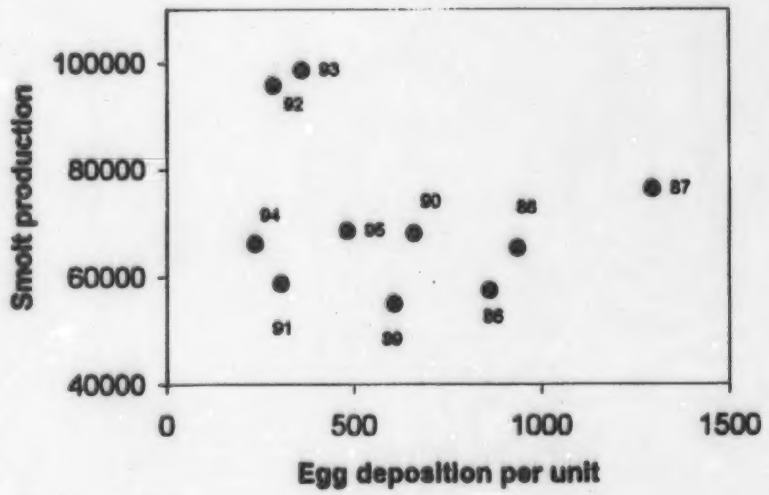
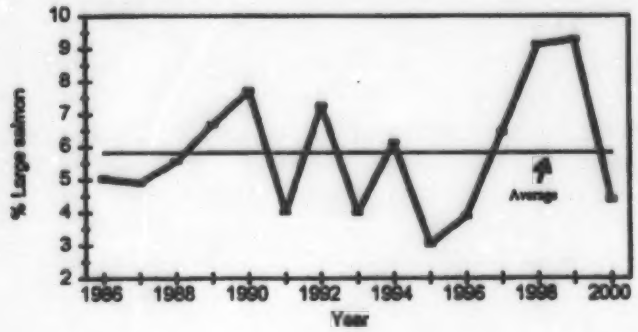


Fig. 10. Relationship between smolt production and the egg deposition rate per unit of fluvial habitat for Conne River, Newfoundland. Year shown refers to year of egg deposition

Appendix - Impact of allowing the retention of large salmon in the angling fishery at Conne River

Abundance

Since 1986, large salmon (≥ 63 cm) enumerated at the Conne River fish counting fence have contributed an average of 5.82% of the number of small (< 63 cm) and large salmon combined, ranging from a low of 3.05% in 1995 to a high of 9.28% in 1999. The contribution varies considerably with no apparent increasing or decreasing trend.



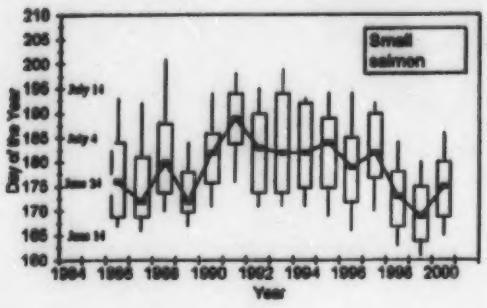
Biological characteristics

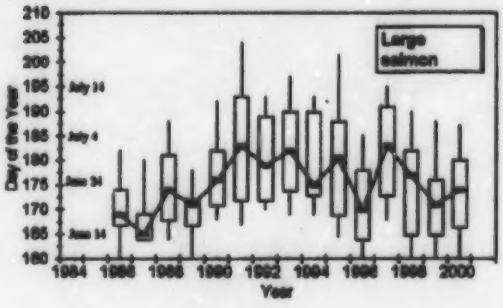
Small salmon at Conne River are predominately maiden one-sea-winter (1SW) fish. Based on a sample of 2521 salmon < 63 cm in length from 1986 to 2000, 93.2% were 1SW salmon and 6.7% consecutive spawning grilse.

Large salmon are predominately alternate spawning grilse. Based on a sample of 170 salmon ≥ 63 cm in length from 1986 to 2000, 75.3% were alternate spawners, 18.2% consecutive spawners and 6.5% 2SW maiden fish. Within the large salmon category, evidence of up to four previous spawning episodes have been noted. Note that the percentage contribution of samples from large salmon (6.3%) is generally similar to the percentage that large salmon constitute of the total count at the fence (5.8%).

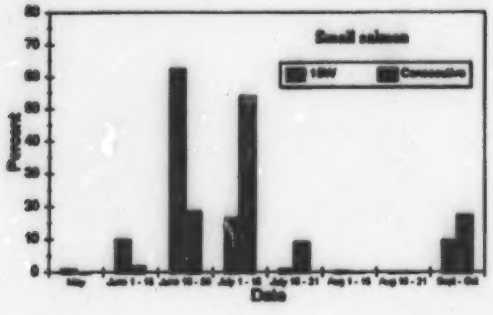
Run timing

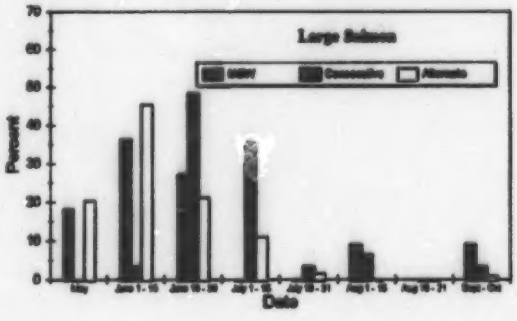
Median run timing of large salmon in 2000 was similar to that of small salmon. From 1986 to 1996, however, median run timing of large salmon was about 5 days earlier than that of small salmon. During the past four year (1997-2000) this pattern has changed with the median run timing now about 2 days later than small salmon. On average, 90% of the run of large salmon is over by July 9 and by July 11 for small salmon. Thus there is little overall difference in run timing of the two size groups.





Over all years within the small salmon size category, consecutive spawners appear to enter the river later, on average than maiden 1SW fish. For large salmon, the few MSW salmon and alternate spawners have a tendency to enter the river earlier than consecutive spawning large fish. Thus when the small and large salmon size categories are separated into respective life-history components, there is some evidence for a small biological separation in run timing.



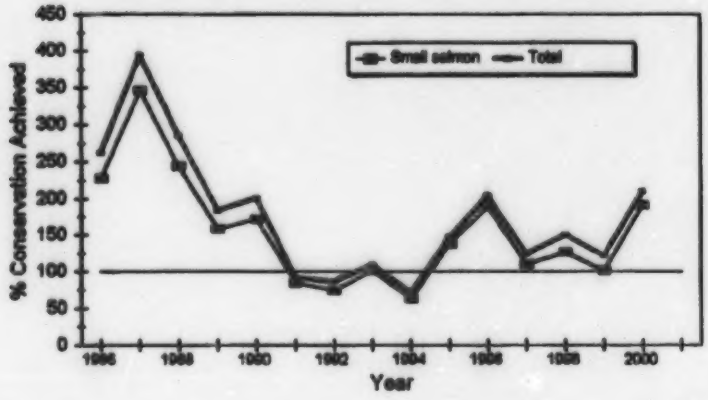


Spawning escapement

Over all years, 1986 to 2000, large salmon have contributed an average of 11.4% of the total estimated number of eggs deposited at Conne River, ranging from a low of 5.8% in 1995 to a high of 16.3% in 1999.

As a '*worst case scenario*' consider that all large salmon were harvested leaving all the egg deposition coming from small salmon. In this case, the total egg deposition would have been reduced, on average, by the same proportions as above, namely 11.4% (5.8 to 16.3%). At present there are three years in which the conservation spawning requirement has not been attained, 1991, 1992, and 1994. In event all large salmon were harvested, these are still the only years in which conservation would not have

been achieved as all other years the contribution from small salmon alone has been sufficient to achieve conservation.



A more likely scenario would be to have an exploitation rate on large salmon of, say, 25%. In this case, an average of 61 large salmon would be harvested annually, ranging from a minimum of 22 to a maximum of 122. The average reduction in the estimated total number of eggs deposited would be 2.8% (1.4 to 4.1%).

During the moratorium years only, 1992 to 2000, the effect that a retention-angling fishery would have had on reducing the average percentage egg deposition attained at hypothetical angling exploitation rates of 10%, 20%, and 30% would have been 1.02%, 2.05%, and 3.07% fewer eggs deposited.

Given the uncertainty as to how many salmon, small or large, survive to spawn after they have been counted, it is evident that having a retention fishery on large salmon at Conne River would have had minimal effects on the overall egg deposition achieved.

STOCK: Conne River (SFA 11) **Drainage area:** 602 km²

MANAGEMENT TARGET: 7.8 million eggs (~ 4,000 small salmon) calculated as fluvial area x 2.4 eggs/m² and lacustrine area x 366 eggs/ha

Year	1995	1996	1997	1998	1999	2000 [2]	MIN [1]	MAX [1]
Total returns to home waters								
Small	3502	4440	3200	2931	2358	5177	1533	10155
Large	110	179	185	295	241	216	89	516
First Peoples' harvest								
Small	0	0	514	0	0	0	0	848
Large	0	0	1	0	0	0	0	11
Recreational harvest (small salmon)								
Retained	-	-	197	-	-	730	108	3302
Released	-	-	80	-	-	-	0	80
Recreational harvest (large salmon)								
Retained	-	-	-	-	-	-	0	27
Released	-	-	0	-	-	-	0	0
Broodstock removal								
Small	117	25	0	0	0	0	25	245
Large	0	0	0	0	0	0	0	1
Spawners								
Small	3376	4402	2558	2926	2346	4431	1435	7823
Large	108	179	182	294	240	216	87	488
Management Target								
% met	82	114	70	84	68	117	40	214
Smolt estimate	62749	94068	100983	69841	63656	60777	55765	100983
% Sea survival (Adult return year)	5.8	7.2	3.4	2.9	3.4	8.1	2.7	10.2

[1] Min and max are for the period of record since 1974. First Peoples' harvest in salt water includes some salmon from other rivers. First Peoples' fishery quota of 1200 fish has been in effect since 1996, but was reduced to 500 fish for 1983. First Peoples' fishery and recreational fishery were closed again in 1998 and 1999.

[2] Preliminary

Data and methodology: Smolt estimates are derived from mark-recapture surveys. Returning adult salmon are enumerated at a fish counting fence. Angling harvets for Conne River are from DFO statistics. A video camera system was introduced in 1993.

State of the stock: The management target, which is higher than the conservation egg requirement, was met from 1996 to 1999 and again in 1996. Only 40-61% of the target was achieved from 1991-1994, but was 117% in 2000. Sea survival to small salmon increased from 3.4% to 8.1%, the highest in more than a decade. In contrast with the mangement target, the conservation egg requirement was met or exceeded from 1995-1990, in 1993, and again from 1995 - 2000.

Forecast: Based upon the point estimate of the number of smolts that migrated in 2000, a marine survival rate of 4.1% would be required in order for the conservation requirement to be attained in 2001, while a survival of 6.6% would be needed to meet the management target. Based upon the sea survival rates that have resulted over the past 13 years, and without any consideration of the trend for lower survivals during the 1990's, the probability of achieving the above returns are 57% and 38%, for the conservation and management targets, respectively.